A Study of the Surface Tension of Blood Serum by the Drop Weight Method

DISSERTATION

BY

HAROLD E. WOODWARD, B. A.

NEW YORK CITY

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SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF PURE SCIENCE IN COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

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CONTENTS

A Study of the Surface Tension of Blood Serum by the Drop Weight Method

Ascoli and Izar* have shown that the immunizing reaction in pathological blood serum is accompanied by a lowering of the surface tension of the serum. They used Traube's stalagmometer, working at room temperature, and observed the change in the number of drops in a given volume of the serum after the immunity reaction had taken place. It seemd advisable to confirm this change, which they cald the Meiostagmin reaction, by the more accurate drop weight apparatus of Morgan.† At the same time it was thought that an accurate study of the surface tension of normal and pathological blood serum might be valuable, and that there might be a normal value for the surface tension of the blood serum of all mammals.

In mesuring surface tension by such methods as capillary rise or the drop method (stalagmometer), the density of the liquid must be used to change the height of the liquid in the capillary tube or the drop volume to surface tension. But since drop weights from any one tip are proportional to surface tensions, for any liquid and any temperature, it is only necessary to get the weight of the falling drop, thus avoiding the error and difficulty of determining densities. From drop weights then we have

$$\gamma = \text{weight} \times \text{constant}$$

This work, which is necessarily rather fragmentary, is divided into the following parts,—

*Juhnke, *Interstate Medical Journal*, *18*, 233, (Feb. 1911)

†Morgan, *Jour. Amer. Chem. Soc.* *32*, 349 (1911)

I Surface tension of blood serum.
  A— Dog serum; the condition of the dog being controld.
  B— Human serum, normal and pathological.
  C— Comparison of different animal sera.

II The Meiostagmin reaction; the decrease in surface tension accompanying the union of antibody and antigen.

APPARATUS AND METHOD

The apparatus used is the same as described by Morgan.* For mesuring the drop weight of serum the apparatus was allowd to remain in a constant temperature bath regulated at 37°C. (body temperature) for nearly half an hour, then a drop of the serum was puld over and left hanging for five minutes in order that the air in the weighing vessel should be saturated with its vapor. This drop was then carefully forced back into the supply vessel, which containd about 5 cc. of serum, and a fresh drop was slowly puld over and allowd to fall of its own weight. The weighing vessel was then weighd as usual after condensing the vapor in it by water at room temperature for one minute. Next a blank was run in the same way, except that the drop was not allowd to fall, and by subtracting this weight from the other the correct weight of one drop of the serum was obtaind.

The determinations in the Meiostagmin reaction were made at 0°C. as there is almost no evaporation at that temperature and in order that no reaction should go on in the solution during the determination. Five drops were taken and weighd, and no blanks were necessary.

As in the work on water and solutions, the tip had to be cleand after each determination or the results would be

*Loc. cit.

too low. The cleaning was best done by alkalin permanganate solution followed by chromic acid in diluted sulfuric acid, then the tip was washt with distild water and dried by suction.

Standardization of Tip

One tip was standardized on benzene at 30°. The constant is found by means of a modified Ramsay and Shields equation,

$$K = \frac{W\left(\frac{M}{d}\right)^{2/3}}{t_c - t - 6}$$

in which W=drop weight in milligrams, M=78, d=.86824, and t_c=288 5. Surface tensions may be found from the ratio

$$W : \gamma :: K : K' \quad \text{or} \quad \gamma = \frac{K'}{K} W$$

γ will be in dynes per centimeter, and K′ is the surface tension constant from the Ramsay and Shields formula, K′ = 2.1148.*

Tip I gave the following results with benzene at 30°.

Vessel + 30 drops	Vessel + 5 drops	
11.7112	10.9695	
11.7113	10 9694	25 drops = 0.74182 gram.
11.7114	10.9697	
11.7113	10.9695	1 drop = 0.0296728
11.7114	10.9693	
11.7112		= 29.67 mg.
11.71130	10.96948	

$K = 2.3572$

$$\gamma = \frac{2.1148}{2\ 3572} W = 0.8972\ W$$

*Morgan and McAfee, *Jour. Amer. Chem. Soc. 33*, 1275. (1911)

diameter of tip* $= \frac{2.3572}{.4224} = 5.580$ mm.

Two other tips were standardized on distild water at 37°. The surface tension of water, from

$\gamma = 75.872 - 0.1547t - 0.000222t^2$ is 69.844 at 37°

Tip II gave results as follows,

Vessel + 30 drops	Vessel + 5 drops		
13.2202	11.3082	25 drops	= 1.91208 grams.
13.2207	11.3085		
13.2199	11.3078	1 drop	= 0.0764832
13.2202	11.3082		
13 22025	11.30817		= 76.483 mg.

$\gamma = \frac{69\ 844}{76.483} W = 0.91319\ W$

$K = \frac{2.1148}{.91319} = 2.3158$

diameter of tip $= \frac{2.3158}{.4224} = 5.483$ mm.

Results on Tip III were

Vessel + 30 drops	Vessel + 5 drops		
12.9084	11.0109	25 drops	= 1.8976
12 9085	11.0108		
12.9082	11 0106	1 drop	= 0.075904
12.90837	11.01077		= 75 904 mg.

$\gamma = \frac{69\ 844}{75.904} W = 0.92016\ W$

*Morgan and Cann, *Jour. Amer. Chem. Soc.* 33, 1060 (1911)

$$K = \frac{2.1148}{.92016} = 2.2983$$

$$\text{diameter of tip} = \frac{2.2983}{.4224} = 5.441 \text{ mm.}$$

In order to test the tips with thick viscous liquids somewhat like serum, the drop weights of glycol and sugar solutions were first tried.

Glycol has practically no vapor tension at ordinary temperatures, (b. p. 200°) so 10 drops were weighd without any blank. At 0° glycol is so viscous that it took over thirty minutes to get the ten drops, while the same number of drops of water are generally dropt in less than five minutes.

Results on glycol $(CH_2OH)_2$

Temp.	Tip	10 drops	Average grams	1 drop mgs.	Crit. Temp.	γ
0	I	0.5265				
		0.5266				
		0.5273				
		0.5269	0.52683	52.683	329.5	47.26
		0.5270				
		0.5268				
30	I	0.5051				
		0.5053				
		0.5047	0.50504	50.504	350.0	45.31
		0.5051				
		0.5050				
55	III	0.4728				
		0.4733				
		0.4734	0.4731	47.310	365.9	43.53
		0 4729				

The values for surface tension give, by least squares, the formula, $\gamma = 47.277 - 0.0675t$. Walden's* formula, from capillary rise is

$\gamma = 48.48\ (1 - 0.00205t)$, or $\gamma = 48.48 - 0.0994t$.

*Walden, *Zeits. Phys. Chem. 65*, 143.

The large difference at low temperatures is probably due to the fact that the liquid is so viscous at 0° that the rise in a capillary tube can not be accurately mesured.

Comparison of results

	$\gamma = 47.277 - 0.0675t$	$\gamma = 48\ 48 - 0.0994t$
0	47.28	48.48
30	45.25	45 50
55	43.57	43.01

Sugar solutions at 37°

Tip	5 drops	1 drop	W	γ
	.5 molar			
III	0.3819	0.0770	76.50	70.30
	0 3826	0.0768	76 30	
	0.3829	−.0006		
	0.3825		76.40	
	1 molar			
II	0.3881	0.0780	87.63	70 86
	0.3882	0.0780	77 50	
	0.38815	−.0005	77 56	
	1.5 molar			
III	0.3887	0.0785	77.81	71.67
	0.3894	0.0784	77 95	
	0.38905	=.0005	77.88	
	2 molar			
II	0.3983	0.0804	79.81	72.90
	0.3998	0.0803	79.85	
	0.39905	−.0005	79.83	

The method of least squares applied to these results, with 69.84 as the surface tension of water, gives

$$\gamma = 69.878 + 0.456C + 0.5202C$$

for the surface tension of different concentrations of sugar at 37°. The calculated results from this agree very well with the observd results.

	obs.	calc.	diff.
Water	69.84	69.88	+0.04
0.5 molar sugar	70.30	70.24	−0.06
1 " "	70.86	70.85	−0.01
1.5 " "	71.67	71.73	+0.06
2 " "	72.90	72.87	−0.03
			0 00

DOG BLOOD SERUM

Except for the first three which were used for practis, the dogs were kept in special cages and fed the regular diet (15 gr. meat, 4 gr. cracker meal, 3 gr. lard and 35 cc. water per kilogram of body weight) until they were in normal condition. They were then subjected to various conditions which a person might undergo, such as missing meals, having extra food, loss of blood, action of cathartic, etc., and they were then bled in order to see if the surface tension of the blood serum would change under such conditions.

At first a few mesurements made on defibrinated blood and contrifuged serum, to see if the surface tension was the same in either case. There seemed to be almost no difference, altho a French investigator reported a difference of over 2%. Results on one dog were, with Tip I.

Blood 5 drops	W	γ	Serum 2 drops	W	γ
0.2487	49.66	44.6	0.0991		
0.2479			0.0992	49.56	44.5
			0.0993		
			0.0989		

As the serum was easier to use, and the blood decomposed rather easily, the serum was used alone.

A comparison was then tried between centrifuged and clotted serum, to see if the method of getting the serum made any difference Serum from one dog gave on Tip III.

Centrifuged 1 drop	W	γ	Clotted 1 drop	W	γ
0.0502			0.0499		
0.0502	49.7	45.7	0 0497	49.3	45.4
—.0005			—.0005		

There is thus a little more than half of one percent difference, but as the clotted serum remaind clear longer than the centrifuged, the blood was allowd to clot after No. 7.

EXPERIMENTS ON DOGS

No.	Tip	Dog	1 drop	W	γ	Remarks
1	I	1 Fem.	0.0991			
			0.0992	49.56	44.5	
			0.0993			
			0.0989			
2	I	1 "	0.2560			
			0.2559	51.19	45.9	
			0.2560			
			0.2558			
3	I	2 Male	0.2757			
			0.2765	55.2	49.5	Dog did not eat or
			0.2760			urinate for several
			0.2759			days.
4	II	3 "	0.0502	49.6	45.7	
			0.0499			
5	III	4 Fem.	0.0503			
			0.0500	49.6	45.7	
			0.0503			

6	III	5	Male	0 0494 0 0493	48.9	45.0	
7	III	5	"	0.0502 0.0502	49 7	45 7	Centrifuged
				0.0499 0.0497	49.3	45.4	Clotted
8	III	6	"	0.0500 0.0498	49.4	45.5	
9	III	6	"	0.0498 0.0498	49.3	45.4	Same dog, next day
10	II III	4	Fem.	0.0496 0.0490 0.0491	49 1 48.0	44.8 44.7	Extra meal
11	II III	4	"	0.0496 0.0492 0.0493 0.0491	49 1 48.7	44 8 44.8	Extra meal
12	III	5	Male	0 0499 0 0499	49.4	45.5	No food day before bleeding
13	III	6	"	0 0505 0.0503	49 9	45.9	No food for two days
14	III	6	"	0.0499 0.0497	49.3	54 4	Extra water
15	II III	7	"	0.0508 0.0504	50.3 49.9	45.9 45.9	Did not eat for several days
16	III	8	"	0.0500 0.0502 0.0502	49.7	45.7	10 gr. salt
17	III	9	Fem.	0.04931 0.04930 0.04924	48.8	44.9	10 gr. sugar

18	III	9	"	0.04980 0.04984 0.04968	49.3	45.4	Dose of Magnesium sulfate
19	III	10	"	0.0502 0.0501 0.0501	49.6	45.6	
20	III	10	"	0.0504 0.0503 0.0503	49.8	45.8	Same dog next day

NOTE:—In No. 1 two drops were weighd, and in No. 2 and 3 five drops were weighd in a vessel containing some serum. In the others one drop was weighd in an empty vessel and the weight of the vapor, as a result of several determinations was taken as 0.5 mg.

The first eight experiments show that the normal surface tension of dog blood is about 45.5 dynes per centimeter. The first three vary from this more than the others because the dogs had not been kept in condition.

Experiment 9 was to see if the loss of blood had any effect on the surface tension. The dog was bled about as far as was safe each day (No. 8 and 9), and the surface tension was about the same each day. This experiment was repeated in No. 19 and 20, except that the two bleedings were about 19 hours apart insted of 26 hours. In this shorter time the surface tension had not quite reached its normal value, for the blood was still rather diluted.

In No. 10 and 11 the dog was given an extra meal several hours before the blood was taken. The decrease of about 1.5% shows the effect of the products of digestion, especially fat, on the surface tension of the blood.

In experiments 12 and 13 the dog starvd one and two days, respectively, before the blood was taken. The result in No. 13 shows a rise of about 1% in surface tension as the blood becomes poorer in the products of digestion. The dog in No. 15 refused to eat for several days, and the surface tension in this case confirms the other result.

500 cc. of water given two hours before the bleeding in No. 14 seemd to have no effect on the surface tension, and a good dose of magnesium sulfate, in No. 18, which would remove water from the system, did not seem to cause any change.

In experiment 16 the last meal before bleeding contained a large amount of salt, and the surface tension was raisd a little, as it should be if much salt was taken up by the blood. The effect of sugar in the diet is shown in No. 17, where there is a decided decrease. This may be because glucose lowers the surface tension of solutions.

HUMAN SERUM

The results on human serum are not as satisfactory as those on dog serum, as it has been shown that the amount and kind of food eaten has an effect on the surface tension of the serum, and the conditions governing the human subjects were not regulated, as was the case with the dogs. Most of this serum was obtaind from St. Luke's and Sloan Hospitals, and some was given by fellow workers in the laboratory.

Results on human serum.

No.	Tip	1 drop gr.	W mg.	γ	Remarks
1	I	0.0499			
		0.0500	49.5	44.5	
		0.0500			
2	I	0.2577	51.5	46.2	Placental
		0.2578			
3	II	0 0507	50.3	45.9	"
4	II	0.0511			
		0.0514	50.8	46.4	"
		0.0512			

5	II	0.0502 0.0503	49.8	45.5	"
6	II	0.0520 0.0521 0.0520	51.6	47.1	Mict
7	II	0.0530 0.0532	52.6	48.0	Kidney
8	III	0.0563 0.0565	55.9	51.4	Chronic nephritis
9	III	0.0517 0.0519	51.3	47.1	Same, later
10	I	0.0499 0.0501	49.5	45.1	" "
11	III	0.0535 0.0535	53.0	48.8	Loc. atax.
12	III	0 0492	48.7	44.8	Apoplexy
	II	0 0495	49.0	44.7	
13	III	0.0489 0.0491 0.0492	48.6	44.7	J. S. B.
14	III	0.04876 0.04856 0.04863	48.1	44.3	"
15	III	0.0499 0 0498	49.35	45.4	F. R. E.
16	III	0.0506 0.0506 0.05068	50.1	46.1	H. E. W.
17	III	0 04968 0.04952 0.04964	49.1	45.2	"

NOTE:—In all of these, except No. 2 in which five drops were weighd, a single drop was weighd in the empty vessel and the weight of the vapor, as a result of several determinations, was taken as 0.5 mg,

Of these, No. 1—5 and 13—17 are probably quite normal, and give an average value of 45.4 dynes as the surface tension of human serum, but most of them vary considerably from this because the conditions were not controld as was the case with the dogs. The placental sera (No. 2—5) are rather high (average = 46.0), probably because the patients had not been eating as much as the others (average = 45.0). The blood in No. 13 and 14 was obtained in the afternoon while it was taking up the digested food, which is the reason for the low value. No. 15 was obtained about an hour after eating, before the blood could absorb any food. No. 16 was taken at noon—about eighteen hours after eating, since nothing was eaten that morning—while a few days later No. 17 was taken about four hours after eating, thus showing the great variation in one individual at different times of day.

Several of the pathological sera show a higher surface tension than would be expected even from a low diet. In the case of the kidney trouble and nephritis this is probably due to retention of salt, and in the latter it accompanies a high blood pressure.

COMPARISON OF DIFFERENT ANIMAL SERA

The blood serum of horse, rabbit, guinea-pig and sheep was obtaind from Rockefeller Institute and St. Luke's Hospital, for comparison with dog and human serum. The results do not agree as closely as they did on dog serum, since the condition of these animals was not governd quite as carefully as with the dogs.

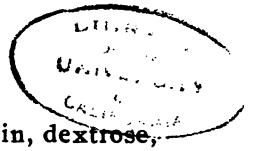
Results on animal serum

No.	Tip	Animal	1 drop	W	γ
1	III	Horse	0.0516		
			0.0514	51.0	46.9
			0.0514		
2		"	0.0488		
			0.0488	48.3	44.5
			0.0488		
3		Rabbit	0.0496	49.1	45.2
			0.0495		
4		"	0.0506	50.1	46.1
			0.0505		
5		"	0.0521	51.6	47.5
			0.0521		
			0.0521		
6		Guinea pig	0.0503	49.8	45.3
			0.0503		
7		Sheep	0.05223	51.7	47.6
			0.05229		
8		"	0.04922	48.8	44.9
			0 04941		

Comparison of surface tensions

Human	from	44.3	to	46.4	av.	45.4
Dog		44.7		45.9		45.3
Horse		44.5		46.9		45.7
Rabbit		45.2		47.5		46.3
Guinea pig		45.3				45.3
Sheep		44.9		47.6		46.2

The surface tension of blood serum is much below that of water, but this is not surprising when the number of substances in solution is considerd. The list includes



neucleoprotein, serum globulin, serum albumin, dextrose, fat, enzymes, lecethin, cholesterol and esters, gases, coloring matter and inorganic salts such as chlorides, phosphates, carbonates and sulfates of sodium potassium and magnesium. The only ones of this list which raise the surface tension of water are the inorganic salts, while the proteins, being colloids, would lower it somewhat and emulsions of fat, lecethin and chloresterol lower it still more.

The surface tension of serum has been mesured by a French investigator* using a stalagmometer. In this method the number of drops of serum in a certain volume is counted and compared with the number of drops of water in the same volume of water as follows—

$$\frac{\text{No. of drops of water} \times \text{density of serum}}{\text{No. of drops of serum}} \times 75 = \text{surface tension}$$

He found it necessary to determine the water "constant" several times a day, so the method can not be very accurate. The use of 75 as the surface tension of water shows that he probably workt at low temperatures (about 5°C), instead of body temperature. His values vary from 69 to 74 (almost equal to pure water), while a few determinations by drop weights at 0° gave about 65. He gave results for different dilutions of serum with water, which do not agree very well. In some cases the very dilute solutions gave results above water, and in others they were nearer the value for undiluted serum. The drop weights of a few solutions of serum were taken, but no irregular curves like those were found. The drop weight work on solutions was not continued, as these did not seem to be any constant cure for dilution, and the very dilute solutions decompose too easily. A knowledge of the surface

*Iscovesco, *Comp. Rend. Soc. Biol. 69,* 353, *70,* 1166, 93, etc.

tension of serum may be of importance in the case of injection of salt solution after loss of blood, as this is generally followd by a fever, since the surface tension of the injected salt solution is higher than that of the serum. It may be that a study of serum diluted with salt solution may be of importance in this connection.

Some Italian investigators* have used the capillary rise method on blood serum, but they worked at nearly all temperatues except body temperature, so the results can not be compared. Both the French and Italian workers have said that the surface tension of the serum is less than that of distild water or isotonic salt solution, and varies according to the species and the individual. The results of this investigation show that the variation in any one individual may be as great as between different individuals, and the value for any individual is about 45 or 46 dynes.

MEIOSTAGMIN REACTION

Ascoli and Izar, of the University of Pavia, who originated the Meiostagmin reaction, showd that when a specific antigen is added to a specific serum, the surface tension of the liquid is lowerd after the antibody, present in the pathological serum, has bound the antigen, by incubation for two hours at 37°. The reaction has been tried on typhoid, syfilis, tuberculosis and cancer serum, being positive in about 90% of the cases which are positive by standard methods, and nearly always negative in negative cases.

This reaction was tried on the drop weight apparatus in a series of syfilis cases—about 25 being positive by the Wassermann and 5 negative. The serum came from St.

*Fano and Mayer, *Arch. di Fisiol. 4*, 165

Luke's and Roosevelt Hospitals, and the Wassermann tests were made in their laboratories. It seemd best to make the determinations at o° instead of at room temperature, so that no reaction would be going on while the determinations were being made, and water was used for diluting since there were no corpuscles present,—otherwise the reaction was carried out according to directions. The reaction does not seem to be as quick as many such reactions. When red blood corpuscles, for example, are treated at o° with an antibody (from the serum of an animal which has been immunized against these corpusclse), and the corpuscles are immediately centrifuged away from the solution, it is found that they have combind with all the antibody in the few seconds that they were together. In the Meiostagmin reaction it takes about two hours for complete union of the antibody and antigen at 37° and there seems to be almost no union at o°.

Izar used alcoholic ethereal splenic extract from a syfilitic fetus for an antigen, but in this work the antigens were mostly from beef heart. The following were used,—

Antigen I The acetone insoluble part of an alcoholic and ethereal extract of beef heart, in alcohol solution. Titrated strength is .04 cc. to .1 cc. of serum.

" II An alcoholic extract of guinea pig heart. Strength is .06 cc. .1 cc. serum.

" III Same as I. Strength is .01 cc. to .1 cc. serum.

The solutions were made up so that the serum was 1 to 25.

Antigen	I 0.2 cc.	II 0.3 cc.	III 0.05 cc.
Water	11.8	11.7	11.95
Serum	0.5	0.5	0.5
Total	12.5	12.5	12.5

Half of the solution was put in the incubator, while the other half was put in the appartus and its surface tension determind at once. The weight of five drops was found and the determination was repeated to get a check within 1 mg.—this allowd an error of about 0.1% and most of the changes were over 0.5%.

It seemd to make no difference whether the serum was inactivated (by heating to 55° for 30 minutes) or not, but most of the samples were inactivated, as they had been used for the Wassermann test in which the serum must contain no complement. In one case the Meiostagmin reaction was tried both before and after inactivation of the serum. Inactivation destroys the complement (which is present in all serum), but leaves the immune body, and it is the latter which is necessary for this reaction.

Tip III — Fresh Serum — Antigen III

Before incubation			After incubation		
5 drops	W	γ	5 drops	W	γ
0.3976			0.3955		
0 3981	79.57	73.22	0.3965	79.20	72.88
0.39785			0.3960		

Same Serum after 30 minutes heating at 55°

0.4072			0.4057		
0.4070	81.42	74 35	0.4047	81.04	74.01
0 4071			0.4052		

Change in both cases is −0.5%

The Meiostagmin reaction works therefore, whether the serum is fresh and contains complement or whether it has lost its complement either by keeping it three or four days or by heating it.

Five non-syfilitic cases were tried, four being negative by the Wassermann test, and the fifth being blood serum of the author which was used as a control.

Tip III · Results on non-syfilitic cases

		Before incubation			After incubation			Change
No.	Ant.	5 drops	W	γ	5 drops	W	γ	%
1	I	0.3753 0.3749 0.3751	75.02	68.51	0.3757 0.3742 0.37495	74.99	68.49	0.
2	II	0.3577 0.3586 0.3581	71.62	65.36	0.3593 0.3600 0.35965	71.93	65.66	+0.3
3	III	0 4056 0.4051 0.40535	81.07	74.60	0.4048 0.4043 0.40455	80.90	74.45	−0.2
4	III	0.4006 0.4010 0.4008	80.16	73.76	0.4008	80.16	73.76	0.
5	III	0.3997 0.4007 0.4002	80.04	73.65	0.3999 0 4005 0.4002	80.04	73.65	0

The negatives do not show more than 0.2% decrease, and that is about the limit of accuracy with these solutions, as it means a check of 0.8 mg. on the weight of five drops before and after incubations. The one in which Antigen II was used, probably showd an increase on account of the large amount of the alcohol solution which had to be used.

Results on positive syfilis

		Before incubation			After incubation			
No.	Ant.	5 drops gr.	W mg.	γ	5 drops gr.	W mg.	γ	Change %
6	I	0.7507 0.7499 0.7503	75.03	69.04	0 7412 0.7416 0.7414	74.14	67.30	−2.5

7		0.3337	66.80	61.00	0.3261	65.23	59.54	—2.4
		0 3343			0.3262			
		0.3340						
8		0 3635	72.67	66.87	0.3565	71.36	65.67	—1.8
		0.3632			0.3571			
		0.36335			0.3568			
9		0.7927	79 30	72.42	0.3969	79.28	72.40	0
		0.7932			0 3959			
		0.79295			0 3964			
10	II	0.3537	70.84	65.15	0.3343	66.92	61.60	—5.5
		0.3547			0.3350			
		0.3542			0.3346			
11		0 3591	71.82	66.07	0.3523	70.46	64 87	—1.8
		0.3591						
12		0.3575	71.42	65.72	0.3550	70.89	65.23	—0 8
		0.3567			0.3539			
		0.3571			0.3544			
13	III	0.3783	75.80	69.75	0.3710	74.26	68.33	—2.
		0.3797			0.3716			
		0.3790			0.3713			
14		0.3963	79.37	73.04	0.3885	77.76	71.55	—2.
		0.3974			0.3881			
		0.3968			0.3883			
15		0.3881	77.53	71.34	0.3818	76.28	70.19	—1.6
		0 3872			0.3810			
		0.3876			0 3814			
16		0.3955	79.06	72.75	0.3914	78.29	72.04	—1.
		0.3951			0 3915			
		0.3953						
17		0.3976	79.57	73.22	0.3955	79.20	72 88	—0.5
		0.3981			0.3965			
		0.3978			0 3960			

18	0.4070	81.34	74.85	0.4053	81.01	74.55	−0.4
	0.4064			0.4048			
	0.4057			0.4050			
19	0.4033	80.64	74.20	0.4025	80.42	74.00	−0.3
	0.4031			0.4017			
	0.4032			0.4021			
20	0.3965	79.26	72.94	0.3951	79.06	72.75	−0.26
	0.3961			0.3955			
	0.3963			0.3953			
21	0.4046	80.96	74.50	0.4039	80.84	74.39	−0.15
	0.4050			0.4045			
	0.4048			0.4042			
22	0.4027	80.60	74.17	0.4027	80.54	74.11	−0.1
	0.4033			0.4027			
	0 4030						
23	0.3909	78.28	72.03	0.3721	74.52	68.57	−4.8
	0.3919			0.3731			
	0.3914			0.3726			
24	0.3949	79.03	72.72	0.3873	77.56	71.37	−1.9
	0.3954			0.3883			
	0.3951			0.3878			
25	0.3985	79.64	73.28	0.3918	78.28	72.03	−1.7
	0 3979			0.3910			
	0.3982			0.3914			
26	0.3992	79.84	73.47	0.3944	78.77	72.49	−1.3
	0.3992			0.3933			
				0 3938			
27	0.4024	80.54	74.10	0.3999	80.04	73.65	−0.6
	0.4030			0.4005			
	0.4027			0.4002			

28	0.3997	79.97	73.59	0.3974	79.58	73.23	—0.3
	0.3990			0.3984			
	0.3993			0.3979			

NOTE:—In No. 6 and the first half of 9, ten drops were weighd, insted of five. No. 7 and 9 were on Tip II, all the others on Tip III. In No. 23—28, the solutions were made up so that the serum was 1 volume in 10, insted of 1 in 25, with apparently no difference in results. Results on four other positive cases which gave a decided decrease in surface tension are ommitted as the results were not checkd very closely on account of the tip not being cleand well enough.

In all but three of these there is a decided decrease in surface tension after incubation, but in No. 9, 21 and 22 the change is no greater than might be found in a negative case, so these can not be calld positive by the Meiostagmin reaction. The history of these three cases, however offers an explanation. No. 9 was a case in which the primary occurd twenty-five years ago, and it was cured at that time by the regular treatment. The Wassermann test was a very weak positive, as titration showd only two units of antibody while an active case contains about eight or ten times as much. No. 22 was a case of tertiary syfilis in which the primary was ten years ago. It gave a positive Wassermann with one antigen and negative with another. The Wassermann test was not tried with the antigen which was used in the Meiostagmin. No. 21 was a case of early tabes probably on syfilitic basis. The Meiostagmin reaction is almost positive, but is very doubtful. No. 20, which gives a weak positive Meiostagmin, gave a doubtful positive Wassermann test. The case had been treated for about eight months with mercury and potassium iodide.

The Meiostagmin reaction is evidently not quite as delicate as the Wassermann at present, tho it probably would be more delicate if the average of three or four determinations were taken insted of two, or if more drops

were weighd. It is a simpler test to make, for it only requires the serum and antigen, while the Wassermann requires inactivated serum, antigen, guinea pig serum for complement, sheep blood corpuscles and rabbit serum which has been injected with sheep corpuscles, all of which must be tested to see if they can be used together.

SUMMARY

1. The surface tension of the blood serum in an individual may change during the day, depending on the food that is being absorbd by the blood.

2. The surface tension of the blood serum of different individuals and different species is approximately the same, if account is taken of the daily change in any one individual.

3. The surface tension of the blood serum seems to be abnormally high in certain diseases, especially those in which the kidneys are affected.

4. The Meiostagmin reaction was found to be specific in about 87% of a series of clinically positive syfilis cases.

5. The clinically positive cases of syfilis in which the Meiostagmin reaction was not positive were those in which the Wassermann test was weak or rather doubtful.

VITA

Harold Edward Woodward was born in Worcester, Massachusetts, July 5, 1888. He receivd the degree of Bachelor of Arts from Amherst College, in June, 1910. Since then he has been studying Chemistry at Columbia University, under the Faculty of Pure Science, for the degree of Doctor of Philosophy. During the year 1910–1911 he taught Chemistry in Horace Mann High School, and he was Samuel Anthony Goldschmidt Fellow in Chemistry for 1911–1912.